Constraining the Properties of Dark Energy using SNAP

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Dark Energy:

Parameterize with

$$\Omega_X = \rho_X/\rho_c \qquad\qquad w = \frac{p_X}{\rho_X}$$

$$H^2(z)/H_0^2 \;=\; \Omega_M(1+z)^3 + \mathbf{\Omega_X}\,\exp\left[3\int_0^z (1+\mathbf{w(z')})\,d\ln(1+z')\right]$$

$$r(z) \;=\; \int_0^z \frac{dz'}{H(z')}$$

- $\dfrac{\ddot{a}}{a} = -\dfrac{4\pi G}{3}(\rho_M + \rho_X + 3p_X)$

  $\Rightarrow p_X$ (and w) are strongly negative

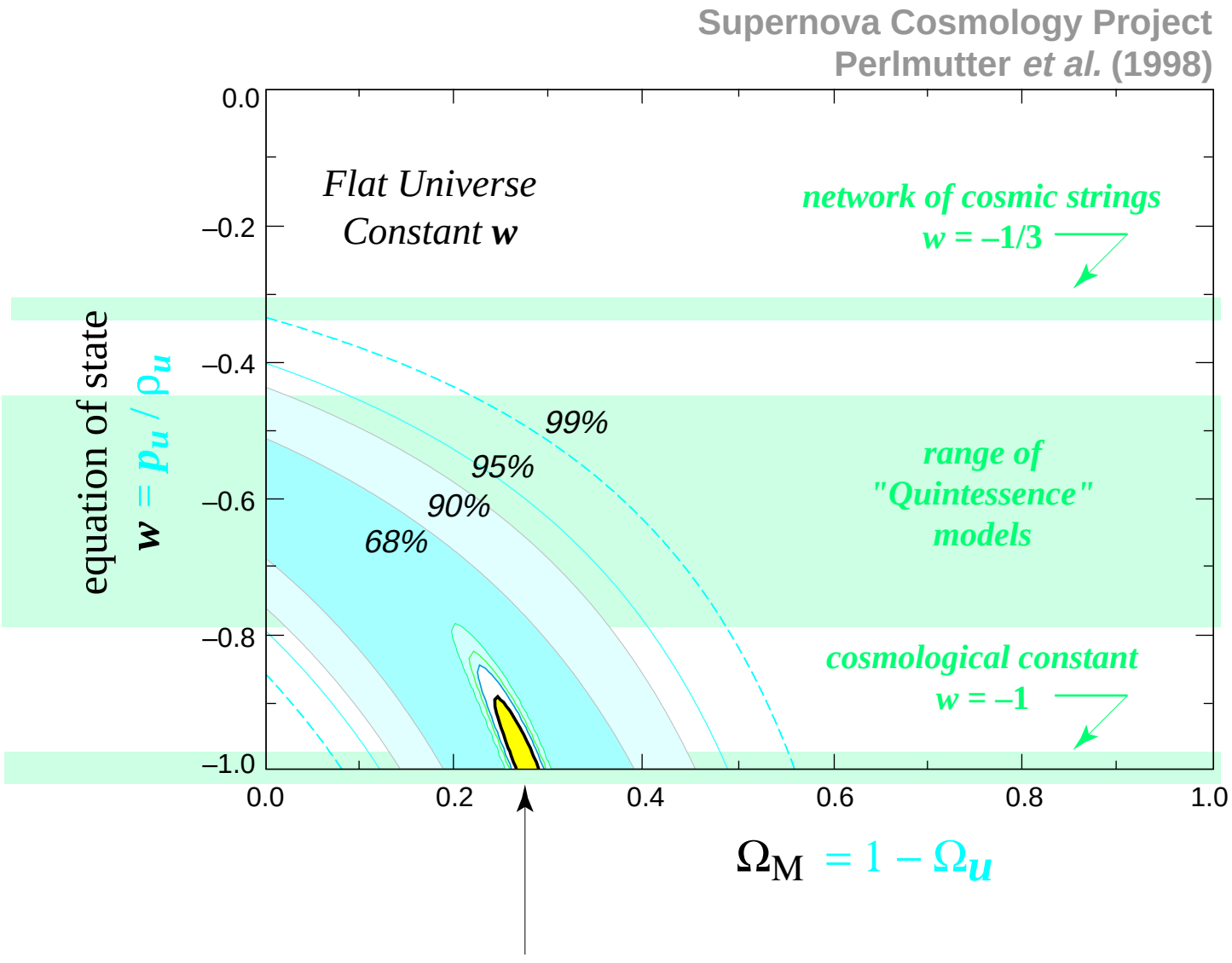
- Current SNe Ia data: $w \lesssim -0.6$

- $\rho_X/\rho_M \propto (1+z)^{3w}$

  $\Rightarrow$ dark energy is important only at $z \lesssim 2$

Dark Energy

Unknown Component, Ω_u, of Energy Density

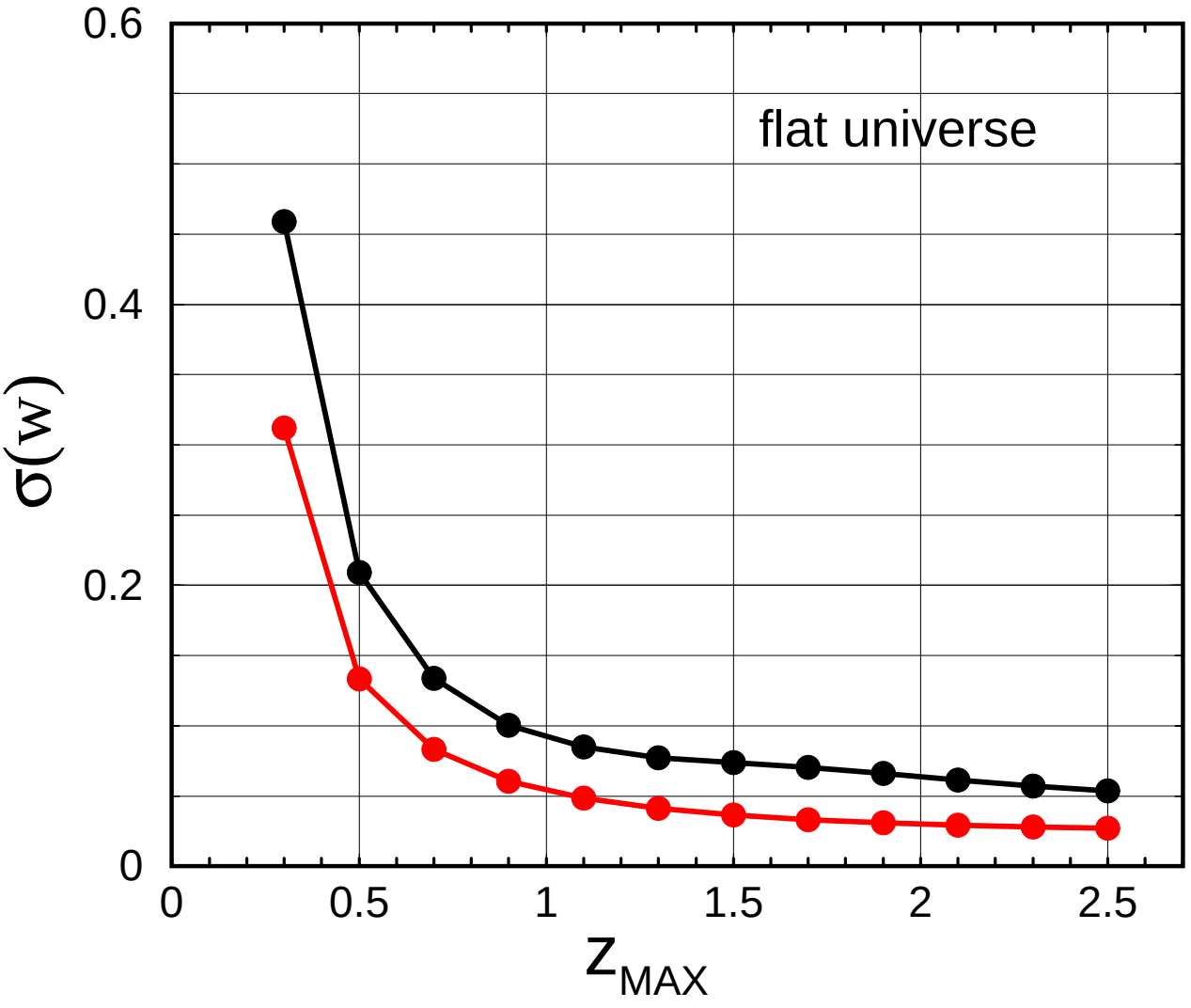


SNAP Satellite
Target Statistical Uncertainty

The Wish List:

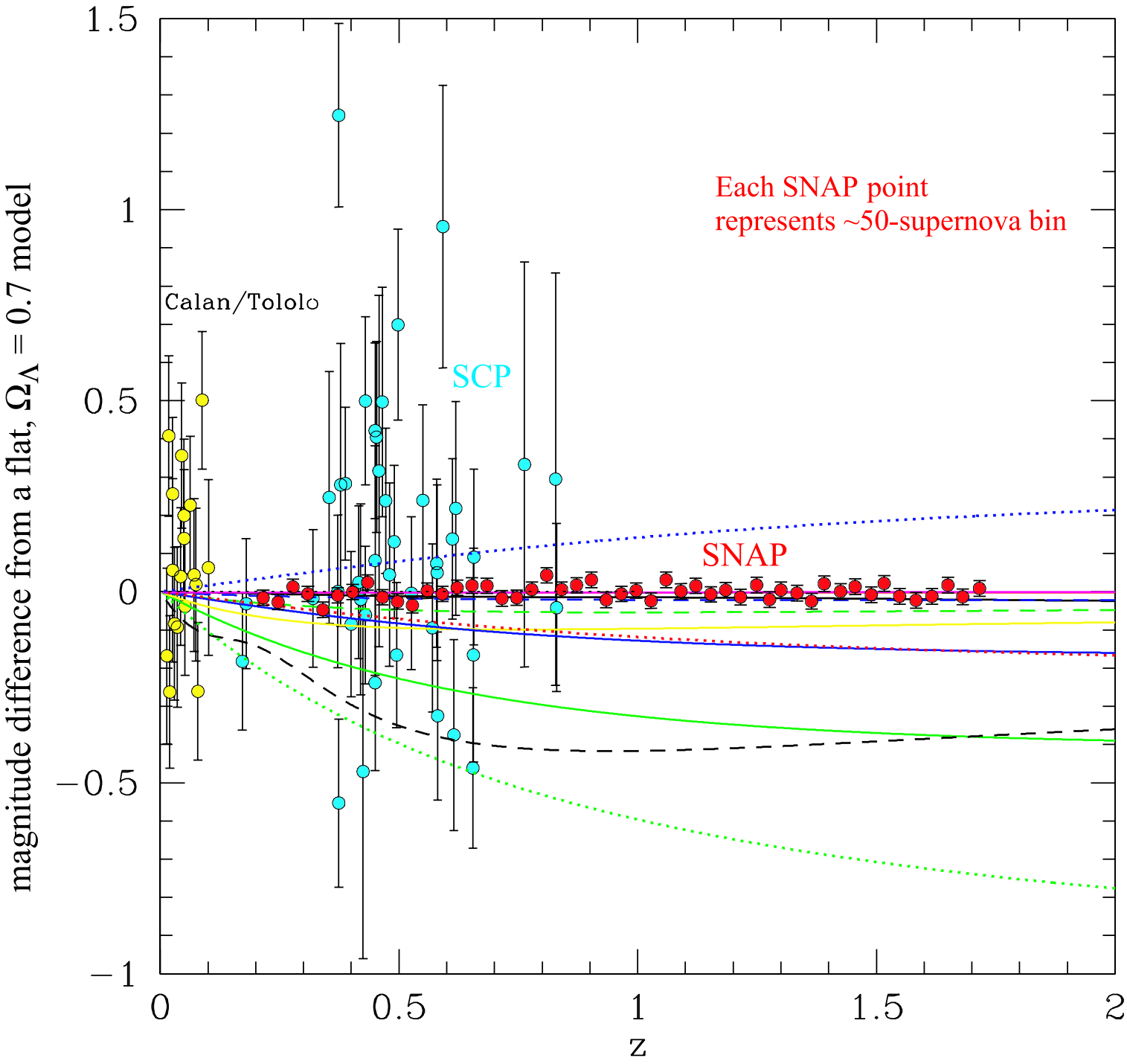
1) A large, well-calibrated set of type Ia SNe...

2) ...covering the interval $0 < z \lesssim 2$



SNAP SuperNova Acceleration Probe

Current ground-based data
compared with binned simulated SNAP data
and a sample of Dark Energy models.



based on
Weller & Albrecht (2001)

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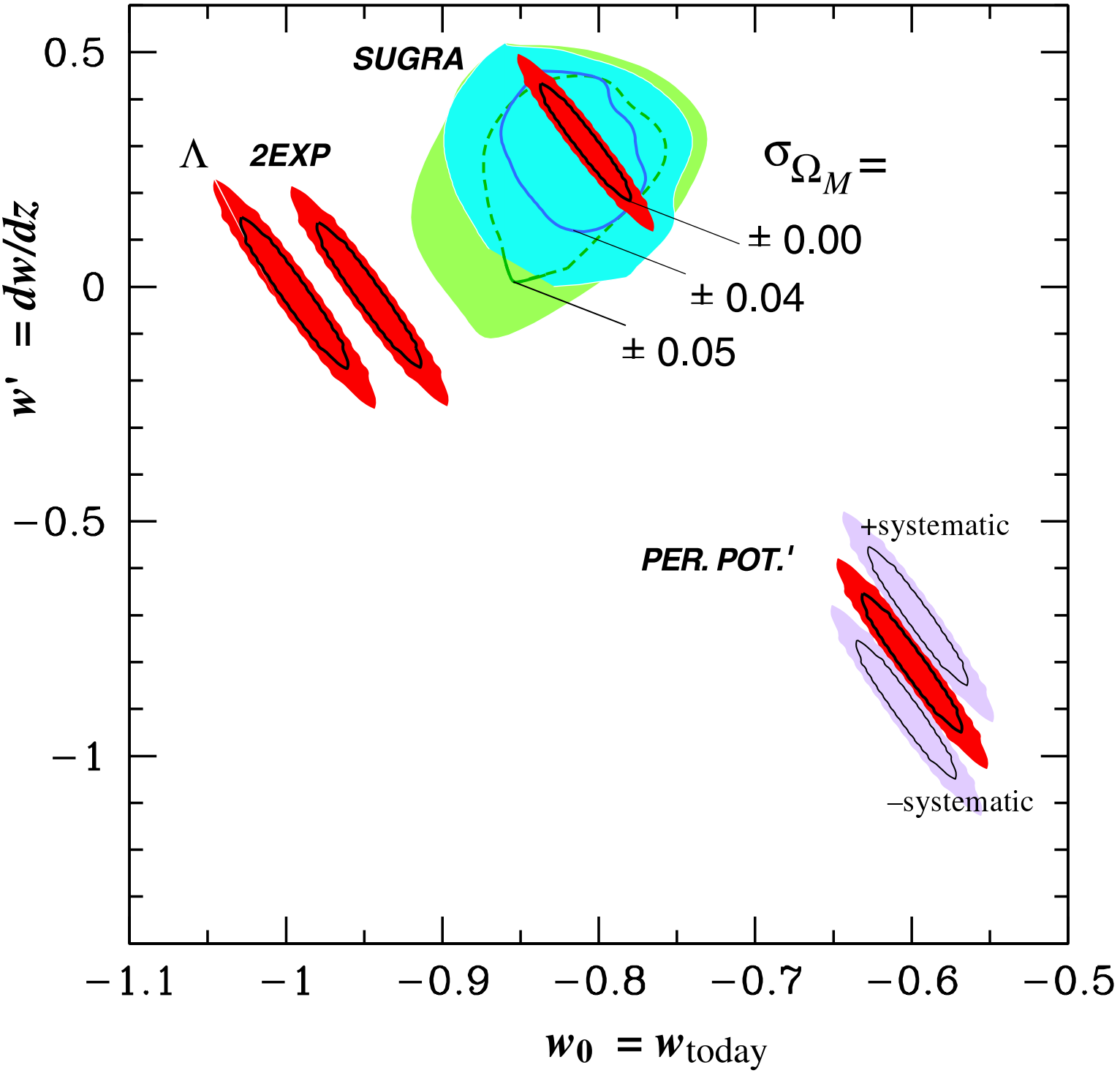
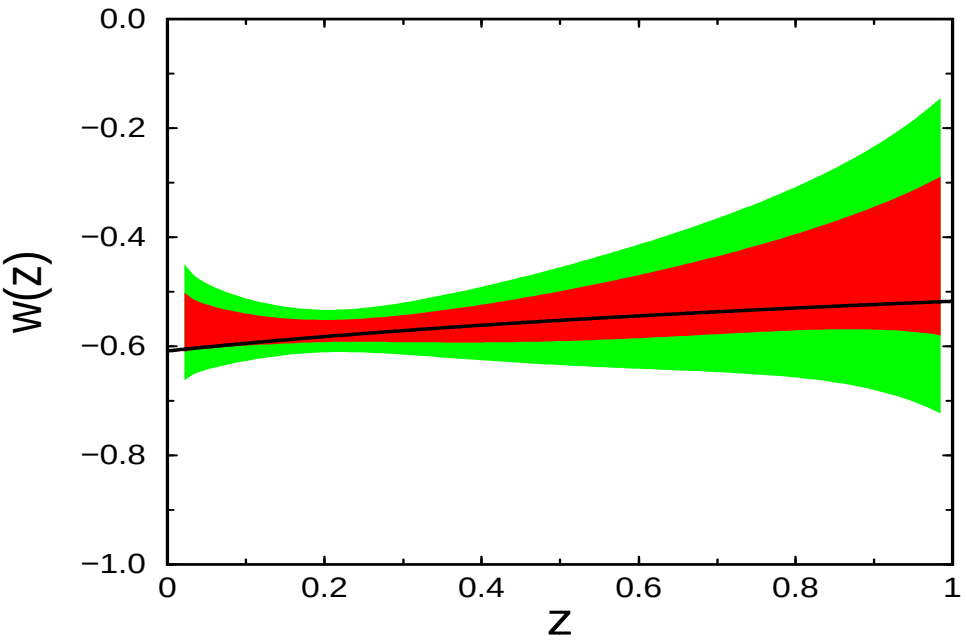


Probing $w(z)$: Reconstruction

(Starobinsky 1998; Huterer and Turner 1999; Chiba and Nakamura 1999)

$$1 + w(z) = \frac{1+z}{3} \frac{3H_0^2\,\Omega_M(1+z)^2 + 2(d^2r/dz^2)/(dr/dz)^3}{H_0^2\,\Omega_M(1+z)^3 - (dr/dz)^{-2}}$$



This approach is:

• **general:** no assumptions about $w(z)$ needed

but also

• **challenging in practice:** Reconstruction depends on the second derivative of $r(z)$. Need to smooth the data first.

Conclusions

- For now, Dark Energy is described by Ω_X and w

- Covering the redshift range $0 < z \lesssim 2$ is crucial:
  a) to break parameter degeneracies
  b) to distinguish between Dark Energy models

- The ultimate goal is to constrain $w(z)$:
  SNAP could constrain w_0 and w' to about 0.03 and 0.12

- Complementary information on Ω_M and Ω_{TOT} will be very important, especially in order to get $w(z)$
  $\Rightarrow$ LSS, CMB
  but also weak lensing with SNAP!